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THE MECHANISM OF DEVELOPMENT OF AORTIC ANEURYSM IN
RABBITS DURING LIMITATION OF THEIR MOBILITY

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16. Abstract Twenty male rabbits of the chinchilla breed were divided into 6 groups and were tested for the development of aortic aneurysm under conditions of limited mobility. Aneurysms were successfully produced in regions where a ligature was applied to the aorta. Two sites for the application of the ligature were chosen; one in the thoracic region and one in the abdominal region. In the thoracic region aneurysms were successfully produced using both the ligature and natural constrictions by the animals' hiatus aorticus. The experiments confirmed that limited mobility in the application of constriction to the aorta produce aneurysms. This is in direct conflict with works published earlier to the effect that constriction alone and applied from the outside will not produce aneurysms. In the case of the abdominal ligature renal disorders are both a result and a contributing factor to the formation of abdominal aneurysm of the aorta.		
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THE MECHANISM OF DEVELOPMENT OF AORTIC ANEURYSM IN
RABBITS DURING LIMITATION OF THEIR MOBILITYV. V. Tyavokin¹

As was reported earlier, we [2-5] duplicated significant changes in the /139* aorta and heart in experiments with limited mobility of rabbits: eroded atherosclerotic plaques, aortic aneurysms, significant stenosis of the lumen of the coronary arteries, necroses in the myocardium. Altering the degree and duration of limitation of mobility of rabbits, one can in a goal-directed fashion duplicate coronary insufficiency in some cases without atherosclerosis and in others, with more long term experiments, one can duplicate coronary insufficiency with atherosclerosis. Coronary insufficiency without atherosclerosis, as a rule, appears during short term (for a period of 3 to 5 days) but sharply limited mobility of the animals. Coronary insufficiency with atherosclerosis develops in comparatively long term experiments with severe limitation of the rabbits' mobility. In connection with the fact that the rabbits do not tolerate sharp limitation of mobility, dying in the early periods of the experiment, with the goal of duplicating atherosclerosis with coronary insufficiency, we alternate severe limitation of mobility of the animals with moderate limitation of mobility or with complete freedom of the animals outside the cages in which they are located during the experiment.

During limited mobility of the rabbits, significant changes arise in the entire organism, primarily in the arteries and heart. Predominant damages to the arteries and heart are related to the fact that general disorders in the organism are combined with local changes. Such general disorders include significant changes in the lipide protein, carbohydrate and mineral metabolisms which appear against a background of diminished functioning of the sympathetic-adrenal system and the adrenal-cortex.

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*Numbers in the margin indicate pagination in the foreign text.

Local changes in the arterial walls in the form of infarction and edema -- the earliest sign of atherosclerosis. The formation of aneurysms is the highest manifestation of changes in the aorta in rabbits during the limitation of their movement. The question arises why in these tests does aortic aneurysm develop in direct proximity to the diaphragm. The comparatively small diameter of the opening in the diaphragm of rabbits attracts attention; the aorta passes through this opening (the hiatus aorticus). In most rabbits, the muscular layers of the diaphragm are joined to the aorta, which makes separation of the aorta from the diaphragm difficult for the experimenter. We selected as a working hypothesis that the most severe changes in the corresponding regions of the aorta are linked to its compression by the diaphragm.

Material and Methods

With the goal of confirming the hypothesis indicated above, tests were set up on 20 male rabbits of the chinchilla breed; these rabbits were divided into 6 groups. All rabbits, under sterile conditions, underwent an operation with placement of a ligature on the thoracic or abdominal region of the aorta. In the 1st through 5th groups, the ligature was placed in the thoracic region of the aorta, in the 6th group on the abdominal region. In the 1st group (2 rabbits), the aorta was not fixed by ligature, i.e., the diameter of the ring formed by the ligature was equal to the diameter of the aorta. In the 2nd group (2 rabbits), the ligature was moderately constricted about the lumen of the aorta and in the 3rd group (2 rabbits) significant contraction of the aortal lumen was carried out. One month after the operation all rabbits of these 3 groups were placed in a special cage constructed by us [3] with the goal of limiting their mobility. Two months after the operation, the rabbits were killed and macroscopic and microscopic changes in the aorta and myocardium were evaluated.

In the 4th group (3 rabbits) the ligature, as in the second group, moderately compressed the lumen of the thoracic region of the aorta. One month following the operation, as in the preceding groups, the rabbits were placed in the cage indicated above with the goal of moderately limiting their mobility, and 2 months after the operation they were killed. This group was distinguished

from the 2nd group of animals by the fact that limitation of mobility of the rabbits was not severe, that their posture was forced. In the 5th group (3 rabbits), as in the 3rd group, the ligature significantly contracted the lumen of the thoracic region of the aorta. The mobility of rabbits of this group, as distinguished from those of the 3rd group, was not limited; the animals were /141 kept in ordinary cages and 2 months after the operation they were killed.

In the 6th group (8 rabbits), the ligature significantly compressed the lumen of the abdominal region of the aorta behind the level of branching of the renal arteries. One month after the operation the animals of this group were subjected to severe limitation of mobility and 2 months after the operation they were killed.

Prior to killing, the arterial pressure in the common carotid artery was measured in all rabbits.

Results of the Investigation

Reports on changes in the aorta and arterial pressure in the rabbits are presented in the table.

An extremely interesting fact is that of the formation of spindle-like aneurysms behind the ligature in both rabbits of the first group (see the figure, A).

In the second group, 2 baglike aneurysms were detected in 1 rabbit: in front of and behind the ligature, and in 1 there was a spindle-shaped aneurysm behind the ligature.

In the 3rd group there were 2 aneurysms in 1 rabbit: a baglike aneurysm in front of the ligature and a diffuse aneurysm behind the ligature (see the figure, B). The 2nd rabbit of this group suddenly died 10 days after the beginning of limited mobility. During its autopsy, a large scale circular aortic aneurysm with rupture and massive hemorrhage into the thoracic cavity was found in front of the ligature (see the drawing, C).

Among rabbits of the 4th group (with moderate limitation of mobility, but kept in forced posture), there were no aneurysms. In the 5th group only 1

rabbit had a slightly expanded aorta in front of and behind the ligature (see the figure, D). In the 6th group not a single animal had an aneurysm.

CHANGES IN THE AORTA AND ARTERIAL PRESSURE IN TEST RABBITS

Group of rabbits	No. of animal	Degree of compression of aorta by ligature	Total duration of limited mobility of rabbits (in days)	Total duration of interruptions in limited mobility of rabbits (in days)	Limitation of mobility of rabbits	Changes in aorta	Arterial pressure (in mm)	Note
1st	1	Ligature did not compress aorta	30	6	Severe	Spindle-shaped aneurysm behind ligature	105	
	2	Ditto	30	5	•	Ditto	103	
2nd	1	Ligature moderately compressed lumen of aorta	30	6	Severe	Two baglike aneurysms: in front of and behind ligature	118	
	2	Ditto	30	8	•	Spindle-shaped aneurysm behind ligature	112	
3rd	1	Ligature significantly compressed lumen of aorta	30	8	Severe	Two aneurysms: in front of ligature - baglike and behind ligature - diffuse	150	Death 10 days after beginning of limitation of mobility
	2	Ditto	10	—	•	Ringlike aneurysm in front of ligature with rupture		
4th	1	Ligature moderately compressed lumen of aorta	30	—	Moderate, but posture of rabbit forced	No aneurysm	118	
	2	Ditto	30	—	Ditto	Ditto	130	
	3	• •	30	—	• •	• •	116	
5th	1	Ligature significantly compressed lumen of aorta	Mobility of rabbits not limited Ditto • •			No aneurysm	128	
	2	Ditto				Slight expansion of aorta in front of and behind ligature	175	
	3	• •				No aneurysm	140	
6th	1	Ligature significantly compressed lumen of abdominal region of aorta	30	7	Severe	No aneurysm	110	
	2	Ditto	30	9	•	Ditto	105	
	3	• •	30	7	•	• •	105	
	4	• •	30	9	•	• •	108	
	5	• •	30	8	•	• •	115	
	6	• •	30	8	•	• •	106	
	7	• •	30	7	•	• •	112	
	8	• •	30	7	•	• •	120	

Discussion

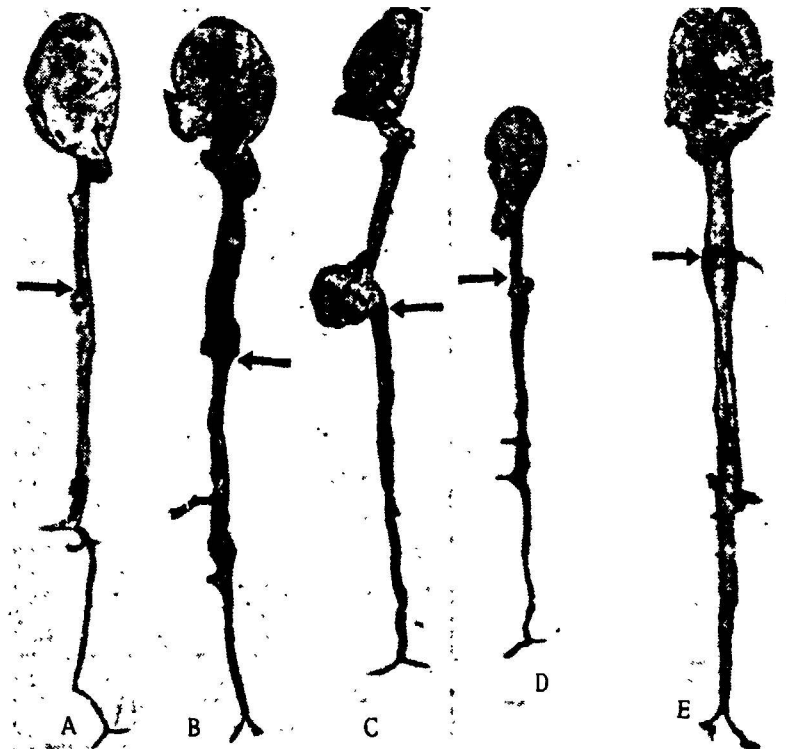
The results of the experiments confirmed our hypothesis: in front of and behind the ligature aortic aneurysms were produced. On the basis of the obtained data, and primarily on the basis of experiments performed on animals of the 1st group, the mechanism of development of aortic aneurysms behind the ligature, and consequently, behind the diaphragm, in the experiments with limited mobility of rabbits is as follows. Severe limitation of mobility of the rabbits causes infarction and edema in the wall of the aorta. In connection with this, the diameter of the aorta increases and this leads to its compression by the diaphragm in the hiatus aorticus and to delayed circulation of the intertissue fluid in the wall of the aorta. There is a deterioration of nutrition of the vascular wall, primarily of its muscular layer, which particularly needs the nutrient substances. Disruption of nutrition in the medial layer of the wall of the aorta can be acute, up to death of the muscle fibers with subsequent development of aneurysms behind the ligature.

In the mechanism of formation of aortic aneurysms in front of the ligature, one of the leading roles is apparently played by increased arterial pressure: /142 in all of the rabbits with aortic aneurysm which developed in front of the ligature, arterial pressure was elevated.

Consequently, the production of aortic aneurysms in our experiments depends basically on 3 factors: 1) the degree of limitation of mobility of the rabbit; 2) localization of the ligature – thoracic or abdominal region of the aorta; 3) degree of compression of the aorta by the ligature. In explaining the development of the aneurysms, these 3 factors should be viewed together. Thus, among rabbits of the 4th group (with moderate limitation of mobility and moderate compression of the aorta) there was no aneurysms, while in the second group with the same degree of aortal compression, but with severe limitation of mobility the animals were found to have aneurysms.

With severe compression of the thoracic region of the aorta of the rabbits, the ligature makes it possible to produce aneurysms without limitation of the animals' mobility, while with the same degree of compression of the abdominal region of the aorta (beyond the level of branching of the renal arteries) and

severe limitation of mobility of the animals, no success was achieved in duplicating aneurysms. This indicates the participation of the renal factor in the development of aortal aneurysm in our experiment. Compression of the aorta by the diagram or the ligature in front of the renal arteries leads to a drop in arterial pressure in the abdominal region of the aorta with subsequent disruption of the renal hemodynamics. In all probability, in connection with ischemia of the renal parenchyma, the juxta glomerular apparatus begins accelerated production of renin, which, acting on the hypertensinogen, converts it to hypertensin, which has pronounced pressor properties. Renal ischemia also leads to the increased liberation of aldosterone by the glomerular zone of the adrenals, and consequently to a decreased excretion of sodium with the urine. Ions of sodium are primarily retained in the wall of the aorta, the arterial walls and the walls of the arterioles, making possible their edematous swelling and stenosis.



Aorta and Heart of the Experimental Rabbits. A, Rabbit no. 1 1st group; B, rabbit no. 1 3rd group; C, rabbit no. 2 3rd group; D, aorta and heart of a growing immature rabbit. Two aneurysms have been produced: behind the constricting ligature and behind the diaphragm; E, aorta and heart of full grown rabbit no. 2 of the 5th group. Explanation in text. Arrows show localization of ligature.

Edematous swelling of the renal arterioles, in connection with their retaining of sodium ions in their walls, increases renal ischemia.

Taking into account the material presented above, one cannot agree with the following categorical assertion of Yu. V. Postnov [1]: "Aneurysmal expansion of the aorta is primarily caused by destruction of the elastic media, and finally and of course, is not linked to constriction of the aorta by the diaphragm as suggested by V. V. Tyavokin. It is known that with application of a constricting ligature to the aorta aneurysm develops as an exception, but not as a rule". In connection with the assertion of Yu. V. Postnov one should note that when applying the constricting ligature to the thoracic region of the /143 aorta of rabbits kept under conditions of severe limitation of mobility it is possible to duplicate aneurysm in every case. Thus, for example, we produced two aneurysms under the conditions of the experiments described above (behind the constricting ligature and behind the diaphragm) and in a growing immature rabbit (see the drawing, D).

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